Study on tracheid variation of *Picea koraiensis* (nakai) in natural stand and plantation

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Abstract: Tracheid characteristics of *Picea koraiensis* from natural stand in Liangshui area and plantation in Mao'ershan area were studied. The results of variance analysis showed that the tracheid length, diameter, and thickness of tracheid wall were significant differences between the growth rings. All those characteristics tend to increase from heart-center to bark. In natural stand, it has positive correlation between the characteristics. In plantation, the tracheid length has positive correlation with the trachied diameter, while both the trachied length and the trachied diameter has negative correlation with the thickness of trachied wall. The tracheid length and diameter have no significant difference in growth between natural stand and plantations. The thickness of tracheid wall from the plantation is a little thicker than that from the natural stand before 15 years.

Key words: *Picea koraiensis* nakai; Plantation; Natural stand; Tracheid characteristic; Variation
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Introduction

Picea koraiensis (nakai) is a species with light color, straight texture, good elasticity and thin structure. It grows quickly and has higher survival rate and very graceful form, thus becoming the main tree species of reforestation in northeast of China (Zhou 1986).

Wood is a kind of natural organic compound, which was composed of cellulose, hemi-cellulose and lignin, but it is uneven in construction. Generally considered, the wood from the same species must have the same structure and physical property. In fact, there are still some differences among different parts of a single tree to some extend, and some wood characteristics have significant variation (Zobel *et al.* 1989; Cheng 1985; Bruce and John 1984; Li and Luan 1993). So the study on variation of wood traits is helpful to understanding the potential value of wood and forecasting wood quality in early stage.

In this paper, tracheid morphological characteristics including tracheid length, tracheid diameter, and thickness of tracheid wall of *Picea koraiensis* from natural stand and plantation are analyzed in order to probe into variation among the growth rings. It is more important to provide reliable information for the tree breeding with fast growth and good wood quality and set up scientific methods for establishing intensive management of this species.

Materials and methods

The three sample trees were selected from natural stand in Liangshui and plantation in Mao'ershan Experimental Station of Northeast Forestry University, respectively.

The 1-m lengths of wood were cut off from the tree at the height of 1 m above the ground, and 0.8-m length was used as study materials. 4-cm discs in thickness were cut. In the center of the disc, 2-cm strip was intercepted in the western direction. The samples were taken every two rings from heart-center outwards for making slices, where the tracheid could be educed by nitric acid (Cheng 1985).

Tracheid length, outer diameter, and inner diameter were measured with microscope. The thickness of tracheid wall was calculated by the following equation (Cheng 1985):

$$R=2(D-d)/d$$

where R stands for the thickness of tracheid wall; D stands for the mean of outer diameter of the tracheid(μm); d stands for the mean of inner diameter of the tracheid(μm).

The ring width was measured to analyze the differentiation among the rings. Besides, analysis of variance, regression and correlation were done by Statistica software.

Results and analysis

Variation of tracheid characteristics in natural forest and plantations

The result of variation analysis indicated that the variations of tracheid length, trachied diameter, and thickness of trachied wall among the rings are extremely significant in both of plantation and natural stand (Table 1). Thus the tracheid growth was very important in wood selection of *Picea koraiensis* in early stage.

Analysis of tracheid growth

The result of regression between the tracheid lengths and rings showed a quantitative change of the tracheid length, which increased from inside to outside of the tree

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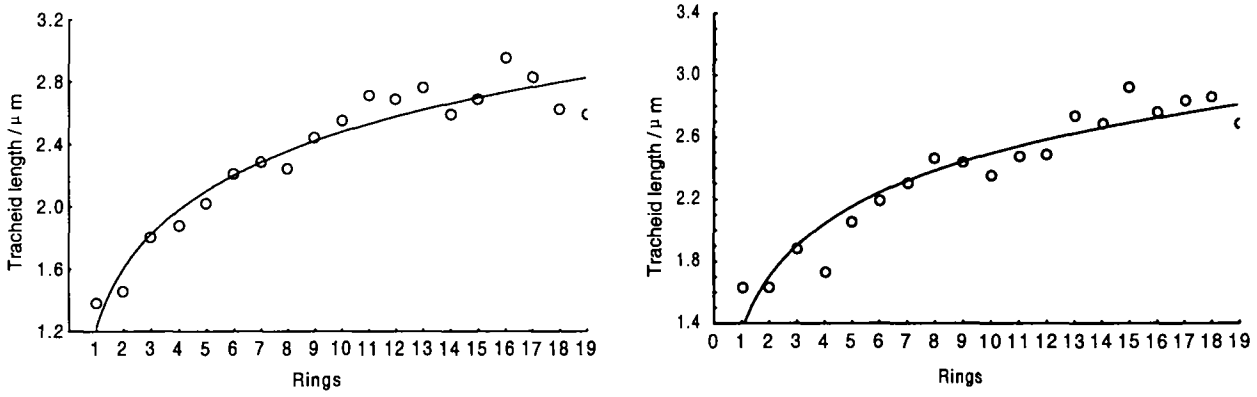
trunk (Fig.1), meantime tracheid lengths and rings had close correlation, with the coefficient of determination of 0.8913 and 0.9720, respectively (Table 2). Normally, this change was consistent with plant physiological nature as that the cambium cells are very active at the initial stage of tree growth, and the primordial maternal cells vertically split so quickly that shorter daughter cells are produced to meet the needs of their fast growth. Therefore, the mean of tracheid length near heart-center is small. With the tree growing, the cambium cells become more and more inactive, and their fission is slower, so that the daughter cells have enough time to be longer (Seth 1981; Zobel and Buijtenen 1989).

Table 1. Variation of tracheid characteristics among the rings

Forest types	Characteristics	F value	Range
Plantation	Tracheid length (μm)	12.12**	1380-2950
	Tracheid diameter (μm)	17.38**	18.62-33.15
	Thickness of tracheid wall (μm)	3.486*	1.28-1.348
Natural stand	Tracheid length (μm)	8.35**	1630-3210
	Tracheid diameter (μm)	22.12**	17.84-36.21
	Thickness of tracheid wall (μm)	4.280**	0.82-1.89



A. The plantation **B. The natural stand**

Fig.1 Regression curves between the tracheid length and rings in plantation and natural stand

Table 2. Regression between the tracheid length and rings

Forest type	Regression equation	Coefficient of determination
Plantation	$Y=1.229+1.248\log10^{x}$	0.8913
Natural stand	$Y=1.305+1.213\log10^{x}$	0.9720

Tracheid diameters increase regularly from heart-center to bark (Fig.2). The result of regression analysis showed that trachied diameter and the rings significantly correlated (Table 3), due to that the size of cell is controlled mainly by plant endorhormone and younger trees have much hormones. At the initial stage, the cambium cell splits quickly and the cell diameter is relatively smaller. In later stage, daughter cells have enough time to grow and develop, so the tracheids diameter from heart-center at a distance is larger (Zobel and Buljtenen 1989).

Table 3. Regression between the tracheid diameter and rings

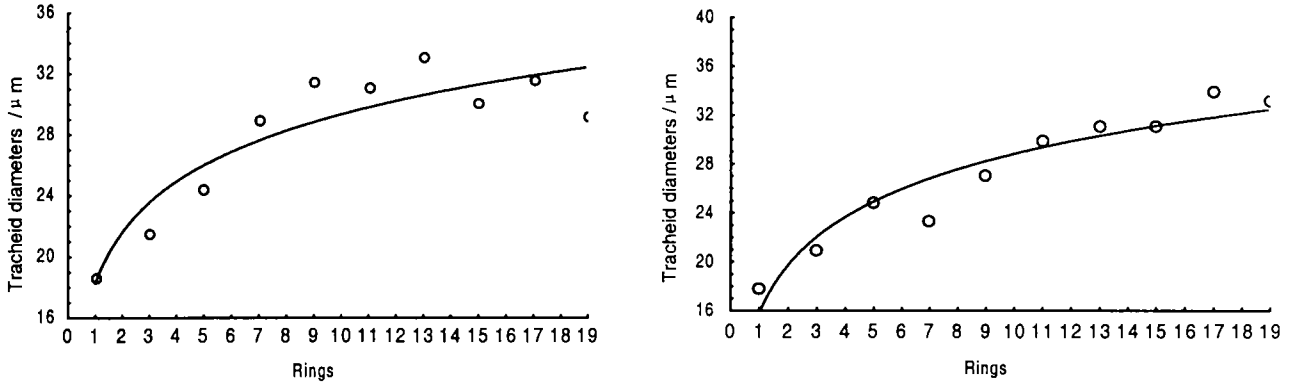
Forest types	Regression equation	Coefficient of determination
Plantation	$Y=18.278+11.06\log10^{x}$	0.7833
Natural stand	$Y=18.06+1.657^{*}X$	0.9708

Besides, the thickness of tracheid wall could affect the physical mechanics feature of the wood and the yield of pulpwood. In this experiment, the thickness of trachied wall rise gradually from heart-center outwards before a certain age, but the regression curve of the thickness of trachied wall with the growth rings does not fit well, compare to that of the trachied length with rings and diameter with rings, because the coefficient of determination of thickness of trachied wall and the growth rings are relatively smaller, 0.71 and 0.88 respectively.

Comparison of tracheid characteristics between natural forest and plantations

There was no significant difference in the tracheid characteristics of the samples from natural forest and plantations, but the mean of the thickness of trachied wall from plantation was a little larger than that from natural stand before the 15th growth ring (Fig. 3-5). The reason probably was that the trees from plantation get better management than that from natural stand in the early stage. After 15 years, the wall thickness of the tree in natural stand is lar-

ger than that of plantation.



A. Plantation **B. Natural stand**

Fig. 2 Regression curves between the tracheid diameters and rings in plantation and natural stand

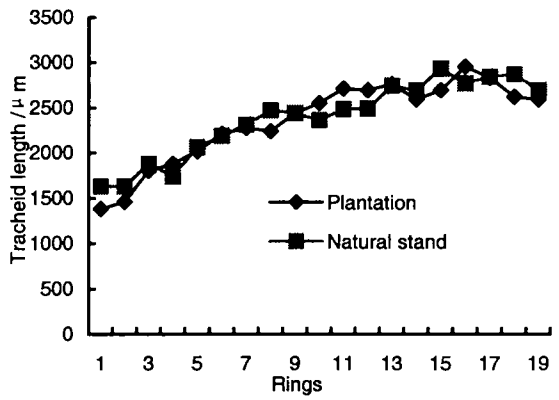


Fig. 3 Comparison between the tracheid length and rings in plantation and natural stand

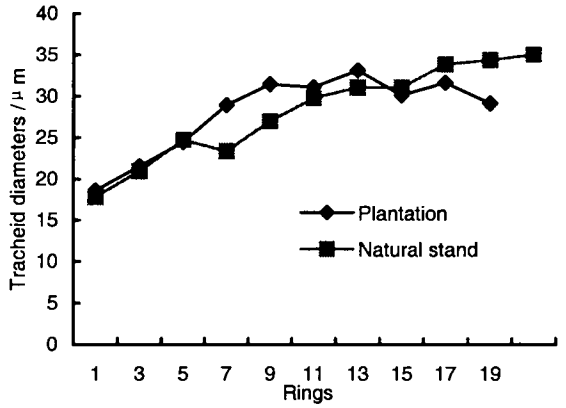


Fig. 4 Comparison between the tracheid diameters and rings in plantation and natural stand

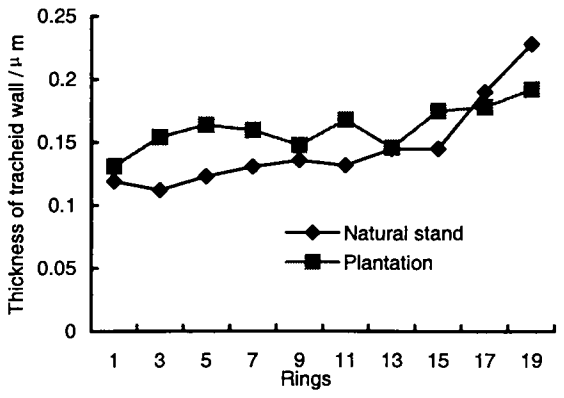


Fig. 5 Comparison between the thickness of tracheid wall and the ring width in plantation and natural stand

The correlation between the tracheid characteristics

The correlation analysis of tracheid characteristics in natural stand showed a positive correlation between the rings and all of the tracheid characteristics. The relationships between the rings and the tracheid length and tracheid diameters reached extremely significant level (Table 5.). At the same time, the tracheid characteristics betweens showed positive correlation, the correlation coefficient between the trachied length and trachied diameter reaches 0.9538. So for the natural stand, the wider the ring is, the bigger in length and diameter the trachied is.

Table 5. Correlation coefficients between tracheid characteristics in natural stand of Liangshui area

Tracheid characteristics	Ring width	Tracheid length	Tracheid diameter
Ring width			
Tracheid length	0.9426**		
Tracheid diameter	0.9674**	0.9538**	
Tracheid wall thickness	0.7197*	0.6005*	0.7645*

Similar to the natural stand, the tracheid length and the diameter demonstrated the closely positive correlation in plantation, and the coefficient is 0.9615. But the relationships between the trachied length and thickness of trachied wall and between the diameter and the thickness of trachied wall all present clearly negative correlation, the coefficients are –0.8746 and -0.8101, respectively. In the

plantation, the thickness of trachied wall tended to be thinner as the tracheid length and the diameter grow faster, and the wood density can be affected by fast growth of the tree. But further study should be done.

Conclusion

For *Picea koraiensis* trees from natural forest and plantations, the tracheid length, trachied diameter, and thickness of trachied wall have significant difference in different rings, all increasing along with the growth ring from heart-center to bark.

There is no significant difference for the tracheid length and trachied diameter between natural stand and plantation. The thickness of tracheid wall from plantation is a little thicker than that from natural stand before a certain age.

In natural stand, between the growth rings and all the trachied characteristics there exists the positive correlation, and so does it between the tracheid characteristics. In plantation, the tracheid length has positive correlation with the trachied diameter, while the thickness of trachied wall and the tracheid length and diameter present negative correlation.

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